

## Claims

- [c1] A reworkable conductive adhesive composition comprising an epoxy based conductive adhesive containing conductive metal filler particles dispersed in a solvent-free hybrid epoxy polymer matrix.
- [c2] The conductive adhesive composition of claim 1 wherein said solvent-free hybrid epoxy polymer matrix comprises a liquid epoxy precursor having a siloxane linkage and carrying an acyclic or alicyclic chain segment, a solid or liquid anhydride or an amine curing additive, and a epoxy curing catalyst, a polymer additive completely miscible in said epoxy precursor.
- [c3] The conductive adhesive composition of claim 1 wherein said metal filler particles are selected from the group consisting of Pd-coated Ag, Au coated Ag, Ag, Ag coated Cu, spherical Ag powder, carbon fibers and carbon microfibers.
- [c4] The conductive adhesive composition of claim 1 wherein said metal filler particles are a combination of a electrically conductive metal and a thermally conductive and electrically insulative inorganic filler.

- [c5] The conductive adhesive composition of claim 4 wherein said thermally conductive and electrically insulative inorganic filler is selected from the group consisting of BN and AlN.
- [c6] The conductive adhesive composition of claim 1 wherein said metal filler particles are metal flakes.
- [c7] The conductive adhesive composition of claim 1 wherein said metal filler particles are metal powder.
- [c8] The conductive adhesive composition of claim 1 wherein said metal filler particles are a blend of metal flake and metal powder.
- [c9] The conductive adhesive composition of claim 1 wherein said metal filler particles are a blend of metal flake, metal powder, and carbon microfibers.
- [c10] The conductive adhesive composition of claim 1 wherein said metal filler particles are hollow spheres.
- [c11] The conductive adhesive composition of claim 1 wherein said metal filler particles are metal fibers.
- [c12] The conductive adhesive composition of claim 4 wherein said metal filler particles are dispersed in said solvent-free hybrid epoxy polymer matrix at a level ranging from

approximately 70 wt. % to approximately 90 wt. %.

- [c13] The conductive adhesive composition of claim 1 wherein said thermally conductive and electrically insulative inorganic filler are dispersed in said solvent-free hybrid epoxy polymer matrix at a level ranging from approximately 80 wt. % to approximately 88 wt. %.
- [c14] The conductive adhesive composition of claim 2 wherein said liquid epoxy precursor is selected from the group consisting of bis(1,3-glycidoxy propyl) tetramethyl disiloxane; aliphatic diglycidyl ethers such as bis(1,4-butane diol) diglycidyl ether and mixture thereof; bis(1,5 glycidoxy propyl)hexamethyl trisiloxane; 1,4-cyclohexane-dimethyl diglycidyl ether and related liquid cycloaliphatic diepoxides.
- [c15] The conductive adhesive composition of claim 2 wherein said anhydride curing additive is selected from the group consisting of hexahydrophthalic anhydride (HHPA); hexahydro-4-methyl phthalic anhydride (MeHHPA); dodecynylsuccinic anhydride (DDSA); octenyl succinic anhydride; hexadecenyl succinic anhydride; cis-4-cyclohexane-1,2dicarboxylic anhydride; cis-1,2,3,6-tetrahydrophthalic anhydride (THPA); methyl-5-norbornene-2,3-dicarboxylic anhydride; maleic anhydride and mixtures thereof.

- [c16] The conductive adhesive composition of claim 2 wherein said polymer additive is selected from the group consisting of poly(n-butylacrylate; n-butylmethacrylate); poly(n-fluorobutyl methacrylate); poly(methyl methacrylate), Poly(acrylonitrile-co-butadiene-co-acrylic acid, dicarboxy terminated glycidyl methacrylate diester (ABA-glycidyl methacrylate diester) oligomer); oligomeric additive amine terminated poly(acrylonitrile-co-butadiene), and mixtures thereof.
- [c17] The conductive adhesive composition of claim 3 wherein said metal filler particle size is less than 10  $\mu\text{m}$ .
- [c18] The conductive adhesive composition of claim 2 wherein said epoxy curing catalyst is selected from the group consisting of 2,4,6-tris(dimethylaminomethyl) phenol; benzyldimethyl amine (BDMA); 2,6-diaminopyridine and a proton source selected from the group consisting of nonylphenol, ethylene glycol, resorcinol, and related materials.
- [c19] A method for making a conductive adhesive composition comprising the steps of;  
mixing a liquid epoxy precursor and a polymer additive to form a first mixture;  
stirring said first mixture at at least room temperature

until it forms a first homogeneous blend;  
adding a anhydride curing additive to said first homogeneous blend to form a second mixture;  
stirring said second mixture at at least room temperature until it forms a second homogeneous blend;  
adding a epoxy curing catalyst to said second homogeneous blend to form a third mixture;  
stirring said third mixture until it forms a third homogeneous blend, and  
adding conductive metal filler particles in said third homogeneous blend to form a  
conductive adhesive composition.

[c20] The method of claim 19 wherein said liquid epoxy precursor is a soluble mixture of 1, 3-bis(glycidoxypropyl) tetramethyl disiloxane and said polymer additive is poly(n-butylmethacrylate) and said first mixture was prepared by heating with stirring at 70°C;  
wherein said anhydride curing additive is a mixture of MeHHPA and HHPA;  
wherein said epoxy curing catalyst is nonylphenol + ethylene glycol, and the tertiary amine 2,4,6-tris(dimethylamino -methyl) phenol (DMP-30); and  
wherein said conductive metal filler particles are Au-coated Ag, Pd-coated Ag filler, Ag flake, or a combination thereof blended to form screenable conductive ad-

hesive paste.

- [c21] The method of claim 20 wherein said polymer additive is present in the range of approximately 10 to 20% (wt%) in the epoxy-polymer additive mixture; wherein said MeHHPA and HHPA mixture ratio is approximately in the range 1:2 to 2:1, respectively; wherein said epoxy catalyst is approximately in the range 0.5 to 1 wt% nonylphenol, 0.1 to 0.5wt% ethylene glycol, and 0.1 to 0.5 wt% DMP-30 or benzyldimethyl amine (BDMA); wherein said Au-coated Ag, Pd-coated Ag, Ag flake or combination thereof is in the range of approximately 77 to 85 wt% of the conductive paste composition.
- [c22] The method of claim 20 wherein said anhydride curing additive comprises a mixture of MeHHP, HHPA, and methylnadic anhydride wherein said methylnadic anhydride is approximately 5–10% (wt%) of the total weight of the anhydride curing agent mixture.
- [c23] The method of claim 20 wherein said anhydride curing additive is DDSA or a mixture of DDSA and MA wherein the DDSA and MA weight ratio is approximately in the range 1:2 to 2:1, respectively.
- [c24] The method of claim 20 wherein said anhydride curing additive is HHPA.

[c25] The method of claim 19 wherein said liquid epoxy precursor is a soluble mixture of 1, 3-bis(glycidoxypropyl) tetramethyl disiloxane and said polymer additive is poly (ABA-glycidyl methacrylate oligomer) and said first mixture is prepared by heating with stirring at approximately 50°C;  
wherein said anhydride curing additive is HHPA, mixture of HHPA and MeHHPA, or HHPA and MA;  
wherein said epoxy curing catalyst is nonylphenol + ethylene glycol, and the tertiary amine 2,4,6-tris(dimethylamino -methyl) phenol (DMP-30);  
wherein said conductive metal filler particles are Au-coated Ag, Pd-coated Ag filler, Ag flake, or a combination thereof blended to form screenable conductive adhesive paste.

[c26] A conductive adhesive rework method comprising the steps of:  
(a) providing a first cleaning solution for a thermal interface cured coating/residue deposit on assembly components which comprises tetramethylammonium fluoride (TMAF) or tetrabutylammonium fluoride (TBAF), or a mixture thereof dissolved in a first essentially water insoluble non-hydroxylic aprotic solvent;  
(b) submerging said assembly components carrying said cured coating/residue of conductive adhesive thermal

interface material in said first cleaning solution heated at approximately 40 to 70°C and allowing said assembly components to be subjected to the cleaning action by said first cleaning solution with stirring or agitation for a first predetermined period of time between about 10 to about 90 minutes;

(c) removing said assembly components from said first cleaning solution;

(d) transporting and submerging said assembly components in a first solvent rinse bath which comprises a hydrophobic non-hydroxylic solvent and subjecting said assembly components to said first solvent rinse at approximately room temperature to 70°C with agitation, for a second predetermined period of time between approximately 5 to 15 minutes, to replace said first cleaning solution on the assembly component surface with said first solvent rinse;

(e) removing said assembly components from said first solvent rinse bath;

(f) transporting and submersing said assembly components to a second solvent rinse bath which comprises a hydrophilic essentially water soluble solvent, and subjecting said assembly components to a second solvent rinse at approximately room temperature to 60°C with agitation such as stirring or immersion spray for approximately 5 to 10 minutes;



(g) removing said assembly components from said second solvent rinse bath;

(h) transporting said assembly components to an aqueous rinse bath and applying a water rinse, spray or immersion spray rinse, at approximately room temperature to 50°C for approximately 2 to 10 minutes;

(i) subjecting said assembly components to a third rinsing step with IPA (isopropanol) to replace water on said component assembly surface with IPA to accelerate drying;

(j) drying said assembly components by blowing dry N<sub>2</sub> or air on the surfaces and then heating said assembly components to approximately 90°C to 120°C for approximately 30 minutes to one hour to remove adsorbed moisture from said assembly components.

[c27] The method of claim 26 wherein said first cleaning solution additionally contains a surface active agent in the amount of approximately 0.1 to 1.0% (wt/vol%) in the cleaning solution.

[c28] The method of claim 27 wherein the surface active agent is a non-ionic surfactant or an amphoteric surfactant, or a combination thereof.

[c29] The method of claim 26 wherein said first essentially water insoluble non-hydroxylic aprotic solvent is propy-

lene glycol methyl ether acetate (PGMEA).

- [c30] The method of claim 26 wherein said water rinse is a deionized water rinse.
- [c31] The method of claim 26 wherein said step of drying said assembly components by blowing dry N<sub>2</sub> or air on the surfaces and then heating said assembly components to approximately 90°C to 120°C for approximately 30 minutes to one hour is performed under vacuum.
- [c32] The method of claim 26 wherein said first solvent rinse bath is selected from the group consisting of propylene glycol methyl ether acetate (PMA), propylene glycol ethyl ether acetate (PGEEA, bp. 158°C), propylene glycol methyl ether propionate (methotate), di(propylene glycol) methyl ether acetate (DPMA, bp. 200°C), ethoxy ethyl propionate (EEP).
- [c33] The method of claim 26 wherein said second solvent rinse bath is selected from the group consisting of di(propylene glycol) methyl ether (DPM, fp 75°C), tri(propylene glycol) monomethyl ether (TPM, fp 96°C), tri(propylene glycol) n propyl ether, or a mixture thereof.
- [c34] An electronic package assembly comprising a substrate having electronic conductors, electronic device chips bonded to substrate and a heat spreader/heat sink at–

tached to back of device chips with a reworkable conductive adhesive composition comprising an epoxy based conductive adhesive containing conductive metal filler particles dispersed in a solvent-free hybrid epoxy polymer matrix.

- [c35] A method for assembling an electronic package wherein a heat sink is attached to the back of device chips with a reworkable conductive adhesive as the thermal interface comprising the steps of:
- applying a thin layer of a reworkable conductive adhesive paste by dispensing or screen printing onto the back of device chips mounted on a chip carrier;
  - securing said adhesive coated chips mounted on a chip carrier in a clamping fixture with slots matching the chip carrier size to prevent any movement;
  - aligning said heat sink with the back of said chips, placing in contact with said adhesive coated chip surface and clamping said heat sink/chip carrier assembly to prevent component movement and provide pressure during subsequent curing;
  - placing said heat sink/chip carrier assembly in a pre-heated oven at approximately 90 to 100°C, holding at this temperature for approximately 45 minutes, then ramping the temperature to approximately 160 to 170°C and holding at this temperature for approximately 60 to

90 minutes to complete cure of the interface adhesive.